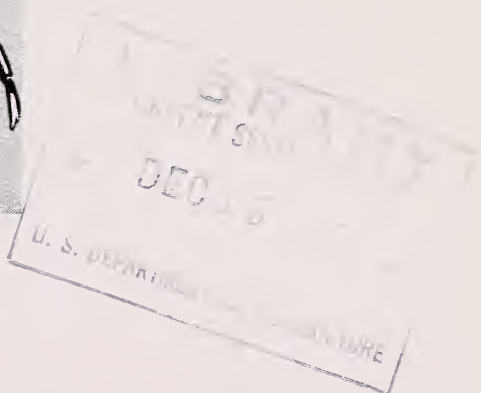


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CONTROLLING the JAPANESE BEETLE



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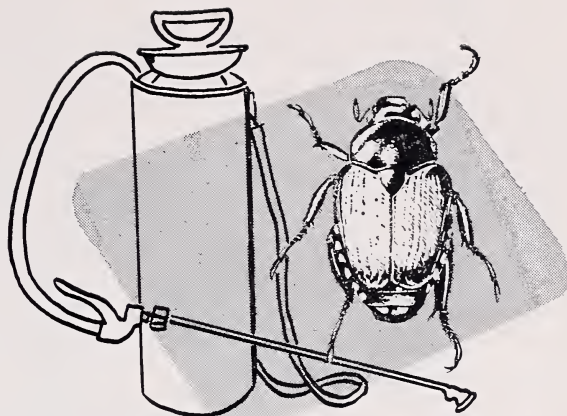
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The Japanese beetle,¹ one of our destructive plant pests of foreign origin, is much more destructive in the United States than in Japan, its native land. Since it was first found in this country, near Riverton, N. J., in 1916 it has increased and spread until, in 1954, it occurred in varying numbers from southern Maine southward into North Carolina and westward into Ohio and West Virginia. Local colonies of the beetle also exist in several other States westward to the Mississippi River.

¹ *Popillia japonica*.

CONTROLLING THE JAPANESE BEETLE



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APPEARANCE, SEASONAL HISTORY, AND HABITS OF THE JAPANESE BEETLE

Plate 1 shows how the Japanese beetle looks in its different stages. Its seasonal history is shown in figure 1.

The Beetles

The beetles are a little less than half an inch long, and a shiny, metallic green, with coppery-brown wings. They can be recognized readily by six small patches of white hairs along each side and the back of the body, just under the edges of the wings.

The beetles first appear on their favorite food plants early in the summer. In eastern North Carolina they begin to come out in mid-May, in the vicinity of Philadelphia about June 15, and in New England about July 1 or later. Their numbers increase steadily for several weeks. The period of greatest beetle activity lasts from 4 to 6 weeks. Then they gradually disappear. In eastern North Carolina most of the beetles are usually gone by the early part of August; in New England some are present until frost.

Japanese beetles fly only in the daytime. They are especially active on warm, sunny days. They feed on the parts of plants or trees exposed to the sun. When feeding on leaves they chew out parts between the veins, giving a lacelike appearance to what is left. Injured leaves soon drop. A badly attacked tree or shrub may lose most of its leaves in a short time. Lists of many of the more important plants, shrubs, and trees, classified according to whether or not they are subject to feeding, are given on page 8.

The beetles are especially fond of ripening fruits. They often mass upon such fruits and feed until nothing eatable is left. They do not usually touch unripe fruit. The beetles injure corn seriously by eating the silk as fast as it grows, which keeps the kernels from forming.

From time to time the females leave the plants on which they have been feeding, burrow about 3 inches into the ground, usually in turf land, lay a few eggs from which the grubs later hatch, and then return to the plants for more feeding. Where there are extensive cultivated areas, the beetles readily lay eggs in soil near plants.

The Grubs

The Japanese beetle spends about 10 months of the year in the ground in the form of a white grub, which feeds on the roots of various plants, especially grasses. When numerous, the grubs may cause serious injury to turf (fig. 2). The grubs of the Japanese beetle are similar to our native white grubs, although generally smaller. When full grown, the grub is about an inch long (fig. 3). It usually lies in the soil in a curled position.

CONTROL OF THE BEETLES

Spraying or Dusting

The foliage and fruit of most plants may be protected from beetle attack by applying sprays or dusts that are toxic to the insect. Timeliness and thoroughness of application are most important. Begin treatment as soon as beetles appear, before damage is done. Apply the treatment thoroughly so that all parts of the plant are well covered by a protective deposit. More than one application may be necessary to maintain effective protection, especially of new foliage and ripening fruit, or if heavy rains occur.

Dilute Sprays

Dilute sprays have been used for many years to control beetles on fruit trees, grapes and small fruits, shade trees, ornamental shrubs, and flowering plants, as well as on corn and soybeans. Several effective materials are now available for use under different conditions, as described below.

Hand sprayers may be used for low-growing plants. High-pressure equipment is necessary to apply the spray properly to fruit and shade trees and to the higher ornamental shrubs. In vineyards and in corn and soybean fields, boom-equipped sprayers have given satisfactory coverage.

DDT is one of the most effective insecticides for killing beetles and protecting plants from attack. Many beetles are killed during the spraying operation; others that come to the sprayed plants, during the period when the residue is effective, are killed by contact. Satisfactory sprays can be made with a 50-percent wettable powder or a 25-percent emulsifiable concentrate. Do not use an oil solution of DDT, as sold for use against household insects, because it may injure plants.

To make a spray, mix the wettable powder or the emulsifiable concentrate with water as follows:

Amount of spray:	50-percent wettable powder	25-percent emulsifiable concentrate
1 gallon-----	1½ tablespoonfuls-----	4 teaspoonfuls.
10 gallons-----	3 ounces-----	6 fluid ounces.
100 gallons-----	2 pounds-----	2 quarts.

If the wettable powder or the emulsifiable concentrate is of a different strength, use a proportional amount. Thoroughly mix the insecticide with water and keep the mixture agitated during spraying.

The use of DDT on plants is often followed by an increase in the number of mites. It has little effect on the mites but destroys their natural enemies. Be prepared to control mites if necessary.

Do not use DDT on berries and vegetables after the edible portion begins to form, or on tree fruits and grapes later than 1 month before picking, or on fodder crops that are to be fed to dairy animals or to animals being fattened for slaughter.

Methoxychlor recently has been found to give good control of the Japanese beetle. It kills beetles more slowly than does DDT and is not so effective in preventing reinfestation of the plants. However, because of its lower toxicity to man and animals, it may be used closer to harvesttime on feed and forage crops and fruits. Refer to the label on the product you use for any cautions as to timing of application for specific crops.

Satisfactory sprays can be made with a 50-percent wettable powder or with a 25-percent emulsifiable concentrate. To make a spray, mix the wettable powder or the emulsifiable concentrate with water as follows:



FIGURE 2.—Dead turf rolled back, exposing Japanese beetle grubs that have been feeding on the roots.

Amount of spray:	50-percent wettable powder	25-percent emulsifiable concentrate
1 gallon-----	3 tablespoonfuls-----	6 teaspoonfuls.
10 gallons-----	5 ounces-----	9 fluid ounces.
100 gallons-----	3 pounds-----	3 quarts.



FIGURE 3.—Full-grown Japanese beetle grub. Six times natural size.

Thoroughly mix the insecticide with water and keep the mixture agitated during spraying.

Parathion for control of Japanese beetles should be used only by the commercial operator or grower who is using the insecticide to control other insect pests. It is highly poisonous to human beings if inhaled, absorbed through the skin, or swallowed, and should be used only by trained operators who are thoroughly familiar with the hazards involved, and who will assume full responsibility and enforce proper precautions. Extreme care must be exercised at all times in handling or using this product.

A spray containing 2 pounds of 25-percent parathion wettable powder to 100 gallons of water is very effective in killing beetles. The deposit on the plants will usually protect them from attack for about 7 days. Make additional applications as the beetles again begin to collect on the plants. Do not use parathion later than 14 days before harvest. Since this interval is inadequate on some crops, refer to the label of the product you are using for information on the approved minimum interval.

Rotenone-bearing materials, such as derris, cube, or timbo, are practically nonpoisonous to human beings and warm-blooded animals. They are of particular value in the home yard in driving beetles away from ripening apples, peaches, plums, cherries, grapes, raspberries and flowering plants.

Use a wettable powder containing 4 percent of rotenone and 12 percent of total extractives. To make a spray, mix the wettable powder with water as follows:

Amount of spray :	<i>Rotenone-bearing materials</i>
1 gallon-----	3 tablespoonfuls.
10 gallons-----	5 ounces.
100 gallons-----	3 pounds.

Apply every 7 to 10 days; rotenone sprays are not effective for a longer time.

Concentrated Sprays

Satisfactory control of the Japanese beetle on large acreages has been attained by applying concentrated sprays of DDT or methoxychlor with aircraft or special ground equipment.

Airplane spraying is the fastest method of covering large acreages of corn or soybeans. Successful application depends on wind movement under 4 miles per hour, discharging the spray not more than 100 feet above the plants, and allowing ample lapping of the swaths. Usually the applications are made early in the morning or late in the evening.

When only the ears of corn are to be harvested, apply the treatment when about one-fourth of the field is in silk, using three-fourths gallon of a 25-percent emulsifiable concentrate of either DDT or methoxychlor diluted with water to 3 gallons for each acre. When the airplane is equipped to handle concentrated suspensions, 3 pounds of a 50-percent wettable powder may be substituted for the emulsifiable concentrate. As a rule, it is necessary to protect corn only during the silking period of 5 to 7 days. One application, properly timed, will usually give control; however, if there are heavy invasions of beetles into the corn from adjacent fields, a second application 2 or 3 days later may be necessary.

Soybeans grown for seed or soil improvement may be sprayed with DDT or methoxychlor. Two or more sprays may be necessary to protect the new growth.

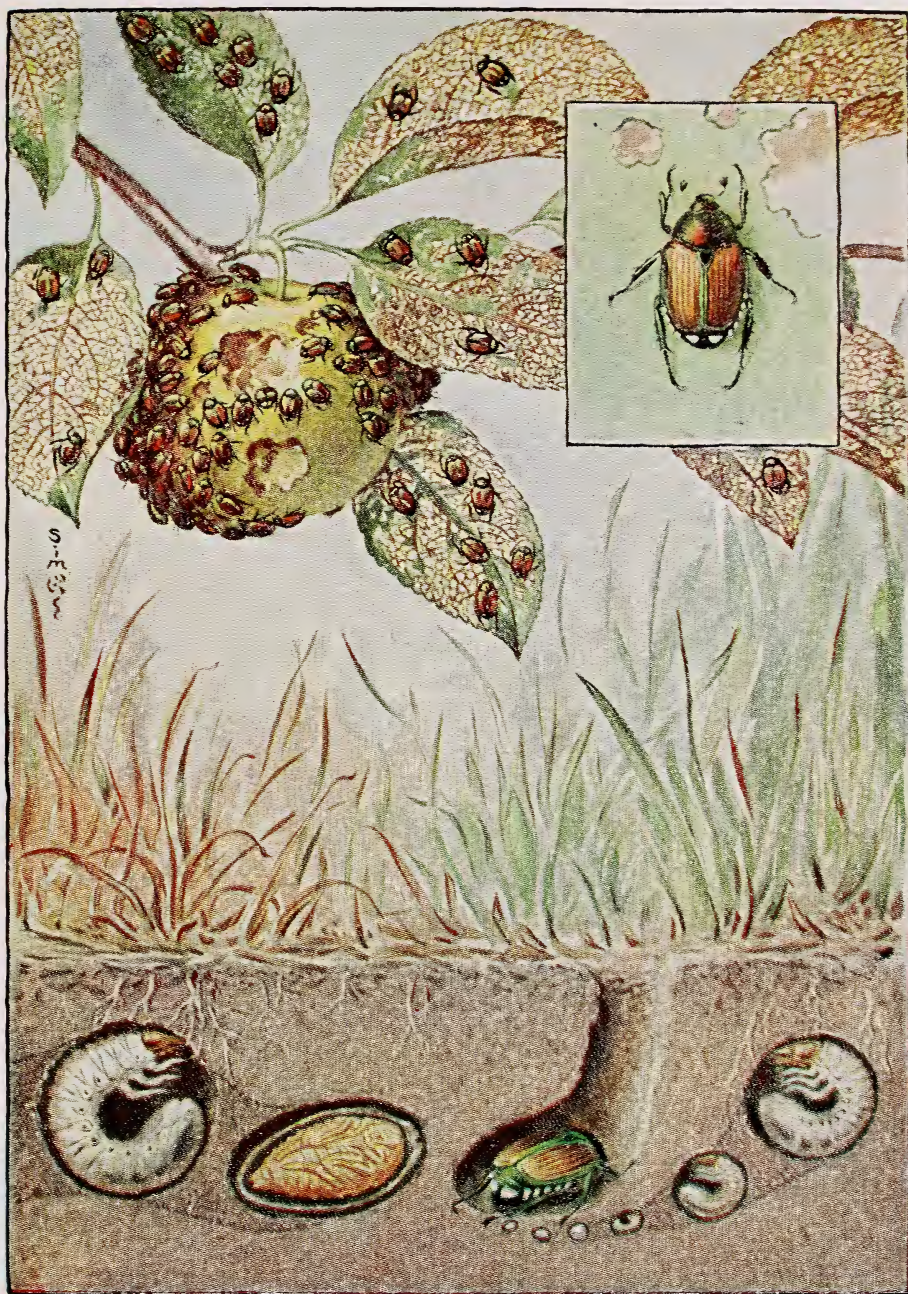
Do not use DDT on corn or soybeans that are to be used for fodder. Use methoxychlor.

Mist blowers, operated from trucks, have been used extensively in the course of cooperative Federal-State control operations for the reduction of populations of Japanese beetles along roadsides and at airports. A 25-percent DDT emulsifiable concentrate diluted with twice its volume of water is usually used in this work. The mist is blown into shrubs and trees as the truck moves along at 2 to 4 miles per hour.

Dusts

Good results may be obtained in large acreages of corn with 30 pounds of a 5-percent DDT or methoxychlor dust per acre, applied by airplane or a row duster. Direct the nozzles of the row duster at the ears. These dusts may be used to advantage also in the home yard when suitable spraying equipment is not available. The dusts must be applied more frequently than the sprays.

When insecticides are not available, or there are objections to using them about the home yard, some protection to the plants can be obtained by dusting frequently with hydrated lime.



Adult beetles feeding on fruit and leaves, about one-half natural size. Insert, adult beetle, about twice natural size. Figures below ground represent seasonal history of the Japanese beetle. Left to right, mature grub (late spring); pupa; beetle laying eggs (summer); developing grubs (late summer and fall); all about twice natural size.

PLATE 1

CAUTION

DDT, methoxychlor, and parathion are poisonous. Handle them with care. Do not use parathion unless you read and follow the cautions furnished with it. Store these insecticides in a dry place where they cannot be reached by children or animals. When used as recommended, formulations of DDT, methoxychlor, parathion, and rotenone are not likely to injure human beings, pets, wildlife, or vegetation. However, do not use these materials in the vicinity of ponds or streams containing fish.

Hand Collection

When only a few small plants are attacked, partial temporary relief from beetle damage may be obtained by collecting the beetles by hand. Jar or shake the shrubs, trees, or individual branches early in the morning, when it is cool and the beetles are quiet. Place a sheet under the plant to catch the beetles as they fall, and drop them into a bucket containing water and a little kerosene. You should do this every day, since more beetles are continually flying in.

Trapping Beetles

Extensive use has been made of traps along the margins of the infested area, airports, and elsewhere to obtain information on the distribution of the insect in connection with cooperative Federal-State efforts to retard its spread to new areas. These traps are painted yellow, and baited with a mixture of 9 parts of anethole and 1 part of eugenol, by volume. Traps are not available for distribution to individuals or community groups.

Where beetles are abundant, traps may catch tremendous numbers without reducing appreciably the damage in the vicinity. In fact, since traps capture less than 25 percent of the beetles in the vicinity and the attractant may draw more beetles into the area, the damage may be increased. Do not use traps to protect plants from attack by beetles.

Cultural Control

Diseased and poorly nourished trees and plants are especially susceptible to attack by beetles. Keep them in a healthy vigorous condition by the proper use of fertilizers and other measures.

Prematurely ripening or diseased fruit is very attractive to beetles. Remove this fruit from the trees and ground. The odor of such fruit attracts beetles, which then attack the sound fruit.

Beetles reduce the yield of corn by feeding on the silk and preventing proper pollination. Corn coming into silk when beetles are not abundant is not subject to serious damage. In some sections it is possible to delay planting to avoid damage. Consult your county agricultural agent with reference to planting dates for your section.

Beetles are very fond of certain weeds and other noneconomic plants, such as bracken, elder, evening primrose, Indian mallow, sassafras, smartweed, wild fox grape, and wild summer grape. These plants in or around a field or orchard are often a continuous source of infestation for the crop. Eliminate them whenever practicable.

Sprays and dusts will not give full protection to such flowers as roses, hollyhock, shrub-althea, and zinnia; they unfold too fast and are especially attractive to beetles. When beetles are the most abundant on the roses, nip the buds and spray the bushes to protect the leaves. When beetles become scarce, let the bushes bloom again.

Utilization of Plants Not Subject to Attack

Although the Japanese beetle will feed on about 275 different plants, it feeds sparingly or not at all on many of the more common trees and plants. When planning new ornamental plantings, or modifying established plantings, make more extensive use of trees, shrubs, and other plants that are not preferred by the beetles. Select kinds least likely to be seriously injured. Use the following lists as guides in selecting plants.

Plants subject to feeding by beetles²

Small fruits: Blackberry, blueberry, currant, grape,* raspberry,* strawberry.
Orchard fruits: Apple,* cherry,* nectarine, peach,* plum, quince.
Truck and garden crops: Asparagus, beans, rhubarb, sweet corn.*
Field crops: Alfalfa, clover, field corn,* soybean.
Ornamental shrubs and vines: Barberry, butterflybush, crapemyrtle, lespedeza, ornamental flowering cherry, rose,* shrub-althea,* Virginia creeper.
Ornamental garden plants: Canna, dahlia,* hollyhock,* marshmallow,* rose-mallow, snapdragon, zinnia.*
Shade trees: Elms, horsechestnut,* linden,* lombardy poplar,* Norway maple,* pin oak, planetree or buttonwood, white birch, willow.*

Plants rarely fed upon by beetles

Small fruits: Dewberry, gooseberry.
Orchard fruits: Pear.
Truck and garden crops: Cabbage, carrots, cauliflower, eggplant, lettuce, onion, parsley, pea, potato, radish, spinach, squash, sweetpotato, tomato, turnip.
Field crops: Barley, oats, rye, wheat.
Ornamental shrubs and vines: Azalea (except deciduous varieties), beautyberry, box, clematis, deutzia, English ivy, euonymus, evergreens, forsythia, honeysuckle, hydrangea, lilac, mockorange, privet, rhododendron, snowberry, spirea, weigela, wisteria.
Ornamental garden plants: Aquilegia, calendula, carnation, chrysanthemum, coreopsis, cosmos, four-o'clock, gladiolus, goldenglow, iris, larkspur, lily, nasturtium, pachysandra, pansy, peony, phlox, snapdragon, sweetpea, tulip, violet.
Shade trees: Ash, Carolina poplar, catalpa, dogwood, evergreens (except cypress), locust, maple (except Norway and Japanese), oaks (except pin and chestnut), redbud, sweetgum, tupelo, white poplar.

CONTROL OF THE GRUBS

Lawns and Golf Courses

The grass in lawns, golf courses, and parks may be protected from injury by grubs of the Japanese beetle for 5 or more years with one application of one of the following dusts:

² Plants marked with an asterisk (*) are especially attractive to beetles.

<i>Dust</i>	<i>Pounds per 1,000 square feet</i>	<i>Pounds per acre</i>
10-percent DDT-----	5¾	250
10-percent toxaphene-----	5¾	250
5-percent chlordane-----	4¾	200
2-percent aldrin-----	3½	150
2-percent dieldrin-----	3½	150
2-percent heptachlor-----	2½	100

The choice of material will be governed largely by availability and cost in the area. When grubs are causing severe damage and quick action is needed to save the turf, use chlordane, aldrin, dieldrin, or heptachlor. It is better to apply the treatment before severe damage has occurred. When there is general foliage feeding by the beetles in the vicinity and an examination of the turf shows that grubs are present, apply one of the dusts to prevent damage. Usually the treatment will kill a high percentage of the fully grown grubs in the turf at the time of application; it will practically eliminate the annual broods which hatch subsequently in the treated turf.

Apply the dust when the infestation is discovered. It may be applied at any time when the ground is not frozen and is best applied by a fertilizer distributor. For hand application to small areas, thoroughly mix the insecticidal dust with several times its volume of sand, soil, fertilizer, or other suitable material, as an aid in distributing it evenly.

Recently these insecticides have been made available in granulated form. The granulated materials usually can be spread more uniformly than the dusts by means of fertilizer distributors. The experimental information on the insecticidal action of these granulated materials is as yet very limited.

It may be of advantage to apply the treatment as a spray. Emulsifiable concentrates or wettable powders of these toxicants mixed with water at rates equivalent to 25 pounds of DDT, 25 pounds of toxaphene, 10 pounds of chlordane, 3 pounds of aldrin, 3 pounds of dieldrin, or 2 pounds of heptachlor per 1,000 gallons, may be substituted for the dry application. Apply as a coarse spray by means of a boom attached to the sprayer, or through hose and nozzle at the rate of 1,000 gallons per acre.

After the dust or spray has been applied to a lawn or in a park, it is advisable to wash the materials into the ground with a hose. Treated turf may be mowed, watered, and fertilized as usual.

DDT, toxaphene, chlordane, aldrin, dieldrin, and heptachlor are poisons. Keep small children and domestic animals away from poisoned grass until it has been watered, or rain has fallen. See Caution, p. 7.

Pastures

The grubs may be very destructive to grasses but rarely feed on the roots of clover and alfalfa. A pasture damaged by grubs may be renovated by sowing a mixture of these legumes. These soon provide a good pasture and are gradually replaced by the original grasses. Consult your county agricultural agent regarding pasture-renovation practices in your area.

The numbers of grubs in a permanent pasture may be reduced to an unimportant or low level by the application of a bacterial dust containing spores of the contagious milky disease. The diseases of the

grubs are discussed in more detail on page 11. The dust containing the spores is available from commercial sources. Apply the dust at any time when the ground is not frozen. Usually the spore dust is applied at the rate of 2 pounds per acre, in spots 10 feet apart. Use about 1 level teaspoonful to each spot. If applied in spots 5 feet apart, the disease will become established more quickly. In this case $7\frac{1}{2}$ pounds of spore dust will be required per acre. For spot treatment of an acre or more, use a hand-operated corn planter with a rotary disk seeder, adjusted to deliver approximately 1 level teaspoonful each time it is tripped. Do not expect immediate results, as several years may elapse before the milky disease becomes fully effective.

Gardens

If flower beds and gardens become seriously infested with grubs, apply DDT or chlordane as suggested for lawns, and then mix it with the upper 3 or 4 inches of soil. Do not apply this treatment to gardens unless necessary, because a few kinds of plants do not grow well in soil treated with these materials.

NATURAL FACTORS LIMITING BEETLE ABUNDANCE

Dry Weather

Extremely dry weather during summer destroys many of the eggs and kills newly hatched grubs. Wet summers are favorable to the development of eggs and grubs, and are usually followed by seasons of increased numbers of beetles.

Insect Parasites

A number of the more important insect parasites that prey upon this pest have been brought in from Asia. Two of them, the spring *Tiphia* (fig. 4) from Chosen (Korea) and the fall *Tiphia* from Japan, have now become well established in the area first inhabited by the Japanese beetles. These are small, wasplike insects, which can live only on the grubs of the Japanese beetle.

For a number of years the Department of Agriculture, in cooperation with State agencies, has been colonizing the more promising parasites of the Japanese beetle at favorable points throughout the infested areas. Thus, over 2,740 colonies had been released in 14 States and the District of Columbia by the close of 1953. These enemies of the beetle gradually spread over infested territory where they become established and are important in the natural control of the beetle. The Department is not in a position to furnish these parasites in response to requests from individuals or local groups.

Diseases

Japanese beetles and grubs have diseases just as people do. The most important one is caused by tiny germs, or bacteria. It kills many grubs. This disease is called milky disease because in a diseased



FIGURE 4.—The spring *Tiphia*, a wasplike insect parasite that lives on and destroys grubs of the Japanese beetle. Six times natural size.

grub the blood, which is usually clear, assumes a milky appearance. The milky disease germs, or spores, live in the soil for long periods, ready to infect and kill successive broods of Japanese beetle grubs as they move about in the soil, feeding on plant roots. Fortunately the disease is harmless to human beings, warm-blooded animals, and plants.

The milky disease occurred only in limited areas in New Jersey and neighboring States when it was first found and studied. In such localities this disease appeared to be an important factor in bringing about a marked reduction in Japanese beetle numbers. However, the spread of the disease seemed to be lagging behind the spread of the beetle. A program for speeding up the spread of the disease and using the milky disease organism in a practical way to reduce Japanese beetle populations was carried on by the Department of Agriculture in cooperation with State and other Federal agencies during the period 1939-53. Almost 137,000 sites were treated with the milky disease organism in 220 counties in 14 States and the District of Columbia.

Marked reductions in beetle infestation have already been observed in most of the earliest treated areas, largely because of the rapid development of the disease-producing organism under favorable conditions. It must be expected generally, however, that several years may elapse before a reduction in well-established beetle populations may be observed. In some localities climatic or other conditions may be unfavorable for rapid establishment and development of the disease organism.

The spore dust should not be applied to soil treated with DDT, toxaphene, or other insecticides. It is unlikely that there will be sufficient grubs in poisoned soil to permit establishment of the disease.

The Department does not have spore dust available for distribution to private individuals or organizations, but several individuals or companies have been licensed by the Secretary of Agriculture to manufacture and sell it. The material is thus available for use by individuals or community groups.

Other Enemies

The numbers of Japanese beetles are sometimes reduced a little by other enemies. Both beetles and grubs are fed upon by several of the more common birds, including starlings and English sparrows. When fields are being plowed, sea gulls and domestic poultry often consume large numbers of grubs. Moles and skunks also feed on the grubs, although they often cause considerable injury to lawns digging for them.

COOPERATIVE REGULATORY PROGRAM

The spread of the Japanese beetle from infested to noninfested areas beyond its flight range is retarded by a cooperative Federal-State regulatory program. In 1954 about 5 percent of the area of the United States was under quarantine because of this beetle, including all of the District of Columbia, Connecticut, Delaware, Maryland, Massachusetts, Pennsylvania, New Jersey, and Rhode Island, and parts of Maine, New Hampshire, New York, Ohio, Vermont, Virginia, West Virginia, and North Carolina. The shipment of any living stage of the beetle outside of this regulated area is prohibited. To give the uninfested areas reasonable protection without placing unreasonable restrictions on industry and the public within the infested areas, several insecticidal treatments and other procedures have been developed to eliminate the living insect in such commodities as soil, nursery and greenhouse stock, and fresh fruits and vegetables. There are methods also for cleaning and treating vehicles and aircraft leaving the infested area.

The nonregulated areas are scouted each year. When an isolated infestation is discovered, sprays are applied to the foliage and insecticides are applied to the soil, and, when necessary, the area is placed under quarantine by the State. In 1954 the beetle was not discovered in any State in which it had not previously been observed.

